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Astronomy Group

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Research Activities

(I) STAR

a. Stellar Structure and Evolution

NAKAMURA computed systematically the Case A evolutions of massive close binary systems. He investigated how the evolution of the system depends on the orbital angular momentum and/or the initial mass ratio of the components and found that the Case A evolutions of the systems can be classified into seven patterns as far as the early phases of evolution are concerned. Contrary to the usual expectation that the massive close binary evolves into contact in consequence of the Case A mass exchange, it has been shown that the systems with fairly wide values of initial parameters evolve into the phases resembling Algol system without passing through the contact phase. It has also been found that, if the system has small orbital angular momentum, the system repeats the mass ratio reversal and subsequent Algol-type semidetached phase in a few times depending on the value of orbital angular momentum and finally fills over the outer critical surface. In the process of this type the contact phase and the Algol-type semidetached phase alternately appear.

b. Pulsating Stars

The group for investigating pulsating stars using hydrodynamic models have succeeded in running the DYN-code, which has been originally constructed at the Los Alamos Scientific Laboratory, on the system ACOS 1000 at the Computer Center of Tohoku University. AIKAWA (Center for Astrophysics, Harvard University), UJI-IYE, OKUDA (Institute of Earth Science, Hakodate College, Hokkaido University of Education) and TAKEUTI[1)] examined a technique to find the limiting-amplitude promptly and described the modulation appeared at the earlier stage of simulation, caused from resonance. They continue to investigate pulsating variable stars using hydrodynamic models.

TAKEUTI and PETERSEN[2] (Copenhagen University Observatory) has applied the resonance hypothesis to study the pulsation of RV Tauri stars using linear, adiabatic pulsation periods. No simple resonance explanation for their characteristic pulsation properties is found. Non-linear investigations seem necessary for a satisfactory description of RV Tauri variables, and several non-linear effects are discussed.

c. Stellar Magnetosphere

The non-ideal MHD effects on the structure of stellar magnetospheres have been investigated for a few years.

KABURAKI[3] has completed the work on the effect of the local pressure gradient which often appears as a plasma disk in certain types of stellar magnetospheres. The self-consistent magneto-disk structure with a given pressure distribution has been obtained in an approximately corotating region where the local pressure force is shown to be balanced by the electromagnetic force and hence the ideal MHD condition is asymptotically recovered. An analytical method to treat the inertial effects of a stellar wind has also been studied by him in general three-dimensional situations, and the formal integral of the equation of motion has been obtained.

SHIBATA and KABURAKI constructed a numerical model of pulsar magnetospheres in which the quasi-neutral wind blows across the magnetic field lines due to the plasma inertia, causing a conspicuous deviation in the electric field from the corotational one. This gives a very good illustration of one of the non-ideal MHD effects on the stellar magnetospheres.

Publications

1) Hydrodynamic Models of Classical Cepheids. I. A Technique to Search the Limiting-Amplitude Oscillation, T. Aikawa, K. Uji-iye, T. Okuda and M. Takeuti, Science Reports Tohoku Univ. 8th Ser. 3 (1982) 82 = Sendai Astronomiaj Raportoj N-ro.246.
2) The Resonance Hypothesis applied to RV Tauri Stars, M. Takeuti and O. Petersen, Astron. Astrophys. 117 (1983) 352 = Sendai Astronomiaj Raportoj N-ro.249.
3) Determination of the Electromagnetic Field produced by a Magnetic Oblique-Rotator. V. Corotating Plasma-Disk, O. Kaburaki, Astrophys. Space Sci. 92 (1983) 113 = Sendai Astronomiaj Raportoj N-ro.254.

(II) GALAXIES AND INTERSTELLAR MATTER

a. Density Wave Theory

The density wave theory, together with the induced galactic shock waves, well explains the observed properties of the spiral structure of galaxies. The density wave is, however, subjected to strong damping processes. Therefore some amplification process is required to maintain the density wave. TOSA[1] made a numerical simulation of the gas flow disturbed by the density wave to study the effect of star formation induced by the galactic shock waves. He examined the mechanical work on the density wave done by the gas through the gravitational interaction and found that the energy released in the gas by the star formation can be converted into the wave energy to provide large enough amplification to maintain the density wave permanently.

SABANO[2] investigated with SAWA, KURITA, and SOBUE (Aichi University) the CO distribution in our Galaxy analyzing the longitude-velocity diagrams of CO emission lines for two longitude ranges $20° < l < 80°$ and $105° < l < 140°$. They compared three typical models for the kinematics of the Galaxy; the circular rotation, the linear density waves, and the galactic shock waves. Their analysis shows that the observed distribution and kinematics of CO clouds are consistent with the predictions of the density wave model and the galactic shock model. This confirms the clain that the CO clouds form spiram spiral arms.

b. Molecular Clouds

FUKUNAGA studied gravitational interaction of Giant Molecular Clouds (GMCs) and found that the random motion of GMCs can be accelerated by a combined effect of the gravitational attraction between GMCs and the differential rotation of the galaxy. His calculation shows that a certain balance is achieved between the acceleration and the dissipation of the random motion to realize a steady state with a random velocity which can explain the observed random velocity of GMCs.

FUKUNAGA[3,4] further pursued the dynamics of a system of GMCs. He treated a system of GMCs as a viscous fluid and calculated evolution of the system of GMCs to reproduce the observed radial distribution of GMCs. His calculation show that the radial distribution of GMCs is correlated with the rotation curve of the galaxy. In a galaxy like ours with two maxima in its rotation curve, GMCs accumulate around two transition regions of the galactic rotation. This explaings the concentrations of GMCs around 5 kpc, the 5 kpc molecular ring, and at the centre of our Galaxy.

SABANO and TOSA[5] studied star formation processes in gas clouds predominated by supersonic turbulence with special regards to collisions of turbulent elements and following formation of compressed gas layer by receeding shock waves. They followed propagation of the shock waves and evolution of the compressed gas layer by one-dimensional gasdynamical simulation until the self-gravity becomes significant. Their result shows that low mass stars of 1 $M_{\odot}$ or less are formed by the collision of turbulent elements in the molecular cloud.

c. Chemical Evolution

DAIDO[6] made a model calculation of chemical evolution of the Galaxy with special regards to the abundance gradient in the halo. He adopted a cylindrical model galaxy in which the gas contracts with a given rate. To reproduce the observed abundance gradient in the galactic halo, he found that the power of mass of the initial mass function is less than unity and that the contraction was decelerated and the galactic disc was formed after a few 10 years from the beginning of the contraction of the Galaxy.

Publications

1) Effect of Star Formation on Galactic Shock Waves and Amplification of Density Wave, M. Tosa, in 'Theoretical Aspects on Structure, Activity, and Evolution of Galaxies', eds. S. Aoki and Y. Yoshii, Tokyo Astronomical Observatory (1983), p.83.
2) On the Spiral Structure in the Galactic Distribution of CO Clouds, T. Sawa, T. Kurita, A. Sobue, and Y. Sabano, Astrophys. Space Sci. 92 (1983) 181 = Sendai Astronomiaj Raportoj N-ro.252.
3) Radial Distribution of Giant Molecular Clouds (GMCs): The Consequences of Viscous Torque of GMC System, M. Fukunaga, Publ. Astron. Soc. Japan 25 (1983) No.2, in press.
4) On the Radial Distribution of Molecular Clouds in Galaxies, M. Fukunaga, in 'Theoretical Aspects, on Structure, Activity, and Evolution of Galaxies', eds. S. Aoki and Y. Yoshii, Tokyo Astronomical Observatory (1983), p.139.
5) Star Formation Driven by Turbulence in the Galaxy, Y. Sabano and M. Tosa, in 'Theoretical Aspects on Structure, Activity, and Evolution of Galaxies', eds. S. Aoki and Y. Yoshii, Tokyo Astronomical Observatory (1983), p.67.
6) Abundance Gradient in the Halo and the Early Evolution of the Galaxy, T. Daido, in 'Theoretical Aspects on Structure, Activity, and Evolution of Galaxies', eds. S. Aoki and Y. Yoshii, Tokyo Astronomical Observatory (1983), p.114.

(III) OBSERVATIONS AND EXPERIMENTS

a. Optical Measurements

TAMURA has continued his observations on several symbiotic stars with 74-inch telescope at Okayama Astrophysical Observatory. Concerning V1329 Cyg (= HBV 475), he[1] accomplished the analysis on IR-photometry data obtained at Agematsu Infrared Observatory (University of Kyoto). In this work it was shown that the low temperature component among its symbiotic consituents has the blackbody-energy distribution, and embedded in the extended ionized material. He also possibly detected violet-shifted absorption and emission lines of FeI and FeII, which may be due to activities of its unstable atmosphere. On the basis of observed data, he proposed a schematic model of it[2].

SHIBATA started his spectroscopic investigation on planetary nebula, M2-9, in order to get informations about the structure and the internal motion.

SEKI and HASEGAWA observed the polarization of some 20 stars around B 361 at various wavelengths using 74-inch telescope of Okayama Astrophysical Observatory. With the data in hand they got some clues on the structure of magnetic field, the relation between the field and gaseous density, and the size of dust particles in this region.

TANIGUCHI and TAMURA published a paper to claim that Markarian 914 is a galactic object, Lick Hα 233, and should be excluded from Markarian list of UV excess galaxies[3].

As an exchange project between CNRS (France) and JSPS (Japan), this year Dr. Jean Heidmann (Observatoire de Paris) has stayed one month from October 30 to November 29. TAMURA and HEIDMANN were devoted to spectroscopic and morphological study on Clumpy Irregular Galaxies. They tried to confirm radio activity in Markarian 297 based on the photographic plate obtained at Kiso Observatory. With the self-scanning diode array detector they also obtained Hγ emission line profile of Markarian 325 to investigate an internal gaseous motion.

In order to elucidate differences between barred(SB) and non-barred(SA) spiral galaxies and effects of the bar on its overall structure, KUMAI, TANIGUCHI, and ISHII investigated various environmental effects for two kind of galaxies. TANIGUCHI and SHIBATA extended their analyses to other sample of galaxies in rich clusters. In collaboration with K. WAKAMATSU (Gifu University), TANIGUCHI and SHIBATA found a new candidata of the prolate bulge galaxy in the cluster, Abell 1931.

b. Radio Measurements

On the start of the period to test 45-m radio telescope system of Nobeyama Radio Observatory, TAKAKUBO, TOSA, and SEKI, in collaboration with HASEGAWA, TANIGUCHI, KAMEYA, and HIRANO, measured molecular lines at two objects: From Bok globule B335 an emission line of HC_3N (J = 1-0, 45.49 GH_z) was detected and of HC_5N (J = 17-16, 45.26 GH_z) was barely detected. From the core of a molecular cloud around NGC 7538 those of CS (48.99 GH_z), $C^{34}S$ (48.21 GH_z), and CH_3OH (48.372, 48.377 GH_z) were detected. The beam size was about 36 sec. of arc at 45 GH_z. The reduction of data obtained is in progress.

Publications

1) Infrared Photometry of HBV 475 (V1329 Cyg), S. Tamura, Publ. Astron. Soc. Japan 35 (1983) 177 = Sendai Astronomiaj Raportoj N-ro.258.
2) HBV 475 as a Condidate Proto-Planetary Nebula, S. Tamura, Proceeding of IAU Symp. No.103 (1983), p.320, University of College London, U.K.
3) Markarian 914 is a Galactic Object, Lick Hα 233, Y. Taniguchi and S. Tamura, Astrophys. Letters 23 (1982) 25 = Sendai Astronomiaj Raportoj N-ro.247.

(IV) NEW INSTRUMENTS

A new type of NALUMI microphotometer, a graphic computer terminal and a hard copy unit (SONY TEXTRONIX 4006-1 and 4611) were purchased.

Doctor Thesis (March 1983)

D1) Dynamics of Molecular Cloud Ensemble in Galaxies, Masataka Fukunaga.

D2) The Evolution of Early-type Close Binaries, Masaomi Nakamura.

Master Thesis (March 1983)

M1) Observations of Molecular Emission Lines on Giant Molecular Clouds, Osamu Kameya.

M2) On the Effect of Environment for Galaxies, Yasuki Kumai.